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Hay Yield, Quality and Competition of Hungarian Vetch (*Vicia pannonica*) and Italian Ryegrass (*Lolium multiflorum*) Intercropping*

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Abstract: A 2-year field study was carried out to determine the hay yield, quality, and competition of Hungarian vetch (*Vicia pannonica* Crantz) and Italian ryegrass (*Lolium multiflorum* Lam.) mixtures at various ratios (100:0, 90:10, 80:20, 70:30, 60:40, 50:50, 40:60; 30:70, 20:80, 10:90, 0:100) in the coastal region of the Black Sea (Ordu, Turkey). The plots were harvested during the filling period of the lower beans in Hungarian vetch. The field experiment was arranged as a randomized complete block design with 4 replications for each year. Hay yield, crude protein ratio and yield, acid detergent fiber (ADF), neutral detergent fiber (NDF), and interspecies competition of the mixtures were determined. It was determined that sole Hungarian vetch planting and Hungarian vetch-Italian ryegrass mixtures had higher hay yield and quality scores compared to sole Italian ryegrass planting. The highest hay and crude protein yield (respectively; 4026 and 732.6 kg ha^{-1}) was obtained from 90% Hungarian vetch + 10% Italian ryegrass mixture and it revealed lower ADF and NDF ratios than any other mixtures. There was no statistical difference between the land equivalent ratio (LER) values of the mixtures; however, Italian ryegrass was found to be more aggressive in the mixtures. These results suggest that, in temperate and rainy regions, 90% Hungarian vetch + 10% Italian ryegrass mixture for winter sowing could be cultured.

Keywords: Forage, aggressivity, intercropping, competition, vetch

1. Introduction

When cool-season annual forage crops are grown for hay yield, they do not change the plant production design. They are also fascinating as a winter secondary crop due to their protective role against erosion when the heavy rains are observed (Demirkol and Yılmaz, 2019). Additionally, these crops eliminate the weed problem during this period (Önal Aşcı et al., 2019).

Hungarian vetch (*Vicia pannonica*) is tolerant to cold and drought stress, and well adapted to heavy clay soils (Lamei et al., 2011). Therefore, the high adaptation to stress conditions increases the importance of the plant especially under the effects of climate change. On the other hand, Hungarian vetch is well recognized as a legume with the potential of increasing soil nitrogen (N) levels. It gives about 100 kg N ha^{-1} to the soil (Acar et al., 2017). However, since the plant has a thin stem, it starts to lodge after flowering. Therefore, intercropping is preferred to eliminate lodging problems. Since natural resources are used more effectively in mixtures, intercropping has been found to be generally more efficient than monoculture. However, in intercropping, there may be competition between species in terms of water, light, and nutrients, and the benefits of mixed cultivation may not emerge. Therefore, it is necessary to determine the appropriate plant species, varieties (Lithourgidis et al., 2011a), and the most suitable mixing ratio (Asci et al., 2015) to provide expected benefits from intercropping.

*: This study was part of the Master Thesis, entitled "Determination of Hay Yield and Quality of Hungarian Vetch (*Vicia pannonica*) and Italian Ryegrass (*Lolium italicum*) as a Mixture with Different Rates" belonging to the second author, accepted by the Graduate School of Natural and Applied Sciences of Ordu University.

Hungarian vetch is generally planted with cool-season cereals as a mixture (Yolcu et al., 2009; Acar et al., 2017). Italian ryegrass (*Lolium multiflorum*) is an alternative plant that can be used instead of cereals in mixtures due to its plenty of leaves and high yield. Additionally, it can be adapted to different soil and environments. Hay yield and crude protein ratio of Italian ryegrass in the Black Sea Region of Turkey were 6660-9370 kg ha^{-1} and 11.46-13.81% (Yavuz et al., 2017).

This study was carried out to determine the hay yield, quality, and competition of Hungarian vetch (*V. pannonica*) and Italian ryegrass (*L. multiflorum*) mixtures.

2. Materials and Methods

The research was conducted in Ordu-Turkey (40°58`13.90 N, 37°56`15.56 E, 6 m altitude) during the growing seasons of 2015-16 and 2016-17. The experiment was established on a soil which has clay loam, salt-free (0.04% and 0.06%), insufficient phosphorus (P) (44.1 and 19.9 kg P_2O_5 ha^{-1}), rich potassium (K) (486 and 511 kg K_2O ha^{-1}), medium and low in organic matter (3.01% and 1.94%) in the first and second year of the experiments, respectively.

The region where the research is conducted has rainy and temperate climatic conditions. The first vegetation period in which the research was conducted was warmer and more rainy than the second year. It was seen that especially in May when plants grow very fast, is the first season was more suitable for plant development in terms of both temperature and precipitation compared to the second year (Figure 1).

In the research, Hungarian vetch (*V. pannonica* L. cv. Kansur) and Italian ryegrass (*L. multiflorum* cv. Caramba) was planted as a mixture (90:10, 80:20, 70:30, 60:40, 50:50, 40:60; 30:70, 20:80, 10:90) or as monoculture by hand on November 4, 2015, and November 26, 2016, in the first and second years (respectively) in rows spaced 20 cm.

The experimental design was a randomized complete block design with four replications. There were 8 rows of 3 m length in each parcel. Sole Hungarian vetch was planted with a seed rate of 80 kg ha^{-1} and sole Italian ryegrass was planted with a seed rate of 40 kg ha^{-1}. The amount of seed in the mixtures was calculated by taking into account the amount of seed used in sole planting. In mixtures, the seeds were planted in the same row. Before seeding, 50 kg N ha^{-1} and 100 kg P_2O_5 ha^{-1} were applied in both years. Plants were grown without supplemental irrigation in both growing seasons. The plots were harvested during the filling period of the lower beans in Hungarian vetch. Italian ryegrass was in the flowering stage at the harvest in both years.

At each harvest, samples were mowed from about 5 cm above the soil surface and separated as Hungarian vetch and Italian ryegrass. The samples for each species from each plot were dried at 70 ºC to a constant weight to determine hay yield (HY). Crude protein (CP), acid detergent fibre (ADF), and neutral detergent fibre (NDF) of samples were determined using near-infrared reflectance spectroscopy (NIRS) (Foss Nir Systems Model 6500 Win ISI II v 1.5). NIRS was calibrated using software program coded IC-0904FE (Önal Aşcı and Eğritaş, 2017). Their weighted averages were also calculated for mixtures. The advantage of

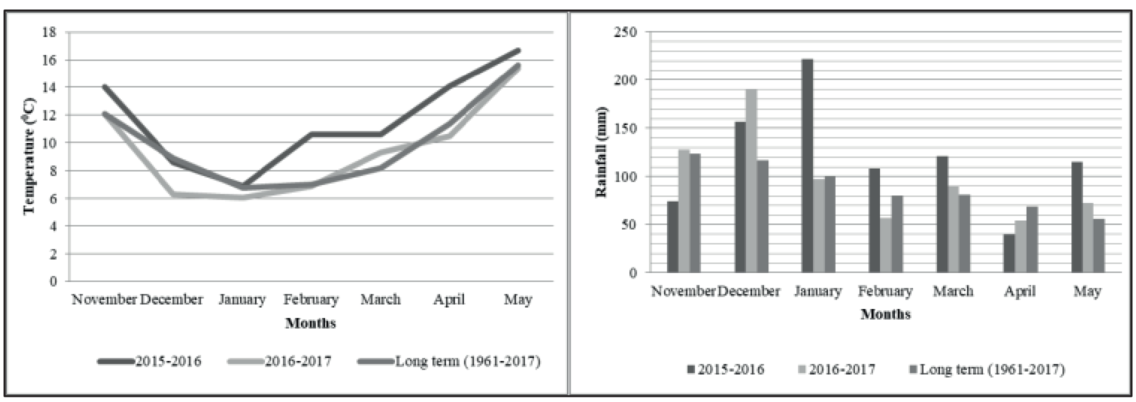

Figure 1. Monthly average air temperature and monthly precipitation in Ordu province

intercropping and the effects of competition between two species used in a mixture was calculated by using differen t competition indices as Equality 1, 2, and 3. The land equivalent ratio (LER), aggressive (A), competition ratio (CR) calculated as:

$$LER = LER_{HV} + LER_{IR} \quad (1)$$

$$LER_{HV} = \left(\frac{Y_{HVi}}{Y_{HV}}\right) \quad (2)$$

$$LER_{IR} = \left(\frac{Y_{IRi}}{Y_{IR}}\right) \quad (3)$$

Where Y_{HV} and Y_{IR} are the yields of Hungarian vetch and Italian ryegrass, respectively as monocrops, and Y_{HVi} ve Y_{IRi} are the yields of Hungarian vetch and Italian ryegrass, respectively as intercrops (Dhima et al., 2007).

LER> 1: the intercropping favors the growth and yield of the intercropped species.

$$A_{IR} = \left(\frac{Y_{IRi}}{Y_{IR}Z_{IRi}}\right) - \left(\frac{Y_{HVi}}{Y_{HV}Z_{HVi}}\right) \quad (4)$$

$$A_{HV} = \left(\frac{Y_{HVi}}{Y_{HV}Z_{HVi}}\right) - \left(\frac{Y_{IRi}}{Y_{IR}Z_{IRi}}\right) \quad (5)$$

Where Z_{IRi} is the sown proportion of Italian ryegrass in the mixture and Z_{HVi} is the sown proportion of Hungarian vetch in the mixture. If $A_{IR} = 0$, both crops are equally competitive, if A_{IR} is positive Italian ryegrass is dominant, if A_{IR} is negative Italian ryegrass is recessive (Dhima et al., 2007; Lithourgidis et al., 2011b).

$$CR_{rI} = \left(\frac{LER_{IR}}{LER_{HV}}\right)\left(\frac{Z_{HVi}}{Z_{RIi}}\right) \quad (6)$$

$$CR_{HV} = \left(\frac{LER_{HV}}{LER_{IR}}\right)\left(\frac{Z_{IRi}}{Z_{HVi}}\right) \quad (7)$$

If CR_{IR} value is less than 1, ryegrass has a positive effect, if CR_{IR} value is greater than 1, ryegrass has a negative effect (Vasilakoglou et al., 2008).

The data were tested for normality using the Shapiro-Wilk test and for homogeneity of variance using Bartlett's test before the analyses. Two-way ANOVA (in replicated randomized complete block design in different years) followed by Tukey's HSD post-test was used to compare the groups. A p-value was considered statistically significant if lower than, or equal to 0.05 (2-sided). All statistical analyses were performed using the Minitab v19 (Minitab Inc., State College, Pennsylvania, USA) statistical software.

3. Results and Discussion

The warmer and rainy days in the May of the first year (Figure 1) and higher organic matter content in the soil caused the plants to produce more biomass. Hay yield in the first year (5143 kg ha^{-1}) was significantly ($p<0.001$) higher than the second year (1481 kg ha^{-1}). As it is known, the root and stem structures of the species planted in the study are different from each other. While Italian ryegrass benefits from a surface and wide soil area with its hairy root structure, Hungarian vetch can benefit better from some nutrients in the soil thanks to its higher root cation exchange capacity. Moreover, the nutrient and climate requirements of the Hungarian vetch and Italian ryegrass are different from each other. All these differences cause the different yields obtained from the sole planting of the plants. In mixtures, the effects of plants on each other may cause positive or negative results. Therefore, statistically significant differences ($p<0.01$) were determined in the hay yield obtained from the treatments. While the yields of all mixtures were higher than the sole planted Italian ryegrass, they were higher or lower than the sole planted Hungarian vetch. Hungarian vetch and Italian ryegrass can tolerate a decrease in the rate of sowing to a certain extent by branching and tillering (respectively). Significant differences were observed especially in the yield of Italian ryegrass in mixtures. Even when the sowing rate in Italian ryegrass was 10%, the yield was almost half of the sole planting (data not shown). The increase in Italian ryegrass in mixtures may arise as a result of biological N fixation in Hungarian vetch or increasing the use of phosphorus in the soil (Chen et al., 2008; Bargaz et al., 2012). On the other hand, in mixtures, Italian ryegrass reduced the lodging problem of Hungarian vetch, therefore, leaf losses were reduced. For all these reasons, the highest hay yield was determined in 90% Hungarian vetch + 10% Italian ryegrass treatment, however, it was statistically in the same group as the other treatments except the 10% Hungarian vetch + 90% Italian ryegrass and 0% Hungarian vetch + 100% Italian ryegrass treatments (Table 1).

Legumes have a higher rate of crude protein than grasses. In addition, environmental conditions affect the crude protein ratio. Therefore, as a result of the variance analysis, a statistically significant difference was found between the years ($p<0.01$ and $p<0.001$) and the treatments ($p<0.001$) in terms of the crude protein ratio and yield. As a result of both the high hay yield and high amount of Hungarian vetch in the first year (data not shown), the mentioned values were higher. As expected, the lowest crude protein ratio was obtained from the sole Italian ryegrass planting. The crude protein ratio increased with the increasing Hungarian vetch content in the hay. In addition, the crude protein ratio of both Hungarian vetch and Italian ryegrass was generally higher in mixtures than sole plantings (data not shown). For all these reasons, the highest crude protein ratio was determined in sole Hungarian vetch and 90% Hungarian vetch + 10% Italian ryegrass treatments (Table 2). The differences in both the hay yield

Table 1. Descriptive statistics and comparisons for total hay yield (kg ha^{-1})

Treatments	2015-2016		2016-2017		Average	
	Mean	SD	Mean	SD	Mean	SD
100HV-0IR	4381.4	660.5	1853.1	553.9	3117.3 abc	1464.5
90HV-10IR	5562.4	952.0	2488.8	352.7	4025.6 a	1772.3
80HV-20IR	5470.1	794.2	1443.5	335.8	3456.8 abc	2225.1
70HV-30IR	5625.4	858.7	1718.2	1329.6	3671.8 ab	2331.4
60HV-40IR	6129.9	546.8	1624.0	247.97	3876.9 ab	2440.3
50HV-50IR	5515.7	1178.7	1441.3	667.1	3478.5 abc	2351.4
40HV-60IR	4842.9	846.9	1324.3	400.2	3083.6 abc	1978.2
30HV-70IR	5252.6	1186.8	1351.8	319.7	3302.2 abc	2234.9
20HV-80IR	4932.2	1517.7	1181.0	588.7	3056.6 abc	2270.7
10HV-90IR	4809.9	565.8	885.8	209.8	2847. bc	2134.4
0HV-100IR	4051.0	405.1	983.4	223.4	2517.2 c	1667.4
Average	5143.0 A	995.0	1481.4 B	654.7		
p	Year= 0.000***, Treatment= 0.001**, Year×Treatment= 0.158					

HV: Hungarian vetch, IR: Italian ryegrass, SD: Standard deviation, **: p<0.01, ***: p<0.001, The difference between treatment means without a small letter is significant (p<0.05), The difference between years means without a capital letter is significant (p<0.05)

Table 2. Descriptive statistics and comparisons for CP (%)

Treatments	2015-2016		2016-2017		Average	
	Mean	SD	Mean	SD	Mean	SD
100HV-0IR	20.70	0.48	19.71	1.32	20.21 a	1.06
90HV-10IR	18.50	1.02	17.73	0.31	18.11 ab	0.81
80HV-20IR	17.78	0.92	15.59	1.46	16.69 bc	1.63
70HV-30IR	17.57	0.34	15.44	2.59	16.51 bcd	2.05
60HV-40IR	15.86	0.78	16.59	0.65	16.23 b-e	0.77
50HV-50IR	16.60	1.11	14.97	3.00	15.78 b-e	2.27
40HV-60IR	15.57	1.02	15.70	2.89	15.64 cde	2.01
30HV-70IR	14.99	0.63	13.49	1.72	14.24 def	1.44
20HV-80IR	15.48	1.57	12.47	0.83	13.97 efg	1.98
10HV-90IR	12.66	0.52	12.56	0.96	12.61 fg	0.71
0HV-100IR	11.86	0.54	11.46	0.85	11.66 g	0.69
Average	16.14 A	2.56	15.07 B	2.82		
p	Year= 0.001**, Treatment= 0.000***, Year×Treatment= 0.280					

HV: Hungarian vetch, IR: Italian ryegrass, SD: Standard deviation, **: p<0.01, ***: p<0.001, The difference between treatment means without a small letter is significant (p<0.05), The difference between years means without a capital letter is significant (p<0.05).

and crude protein ratio of the treatments also affected the crude protein yield. The lowest crude protein yield was obtained from the sole Italian ryegrass planting (Table 3). Similar to our research, Kusvuran et al. (2014) observed the lowest crude protein ratio and yield in sole Italian ryegrass planting out of the mixtures of Hungarian vetch and Italian ryegrass. When the Hungarian

Tablo 3. Descriptive statistics and comparisons for CP yield (kg ha^{-1})

Treatments	2015-2016		2016-2017		Average	
	Mean	SD	Mean	SD	Mean	SD
100HV-0IR	906.73	137.25	366.17	115.23	636.45 ab	311.85
90HV-10IR	1023.92	138.97	441.23	63.24	732.57 a	327.10
80HV-20IR	975.26	171.54	222.75	44.71	599.01 ab	418.64
70HV-30IR	988.66	156.93	289.48	253.07	639.07 ab	421.51
60HV-40IR	971.54	87.57	269.80	44.57	620.67 ab	380.57
50HV-50IR	917.53	220.80	229.49	129.23	573.51 abc	404.11
40HV-60IR	756.00	158.84	209.59	78.50	482.80 bcd	314.26
30HV-70IR	793.11	211.35	184.75	61.79	488.93 bcd	355.70
20HV-80IR	774.35	292.04	149.44	75.51	461.89 bcd	388.03
10HV-90IR	608.84	75.39	110.92	26.43	359.88 cd	271.24
0HV-100IR	479.47	40.57	111.86	20.94	295.67 d	198.76
Average	835.95 A	222.49	235.04 B	134.43		
p	Year= 0.000***, Treatment= 0.000***, Year×Treatment= 0.174					

HV: Hungarian vetch, IR: Italian ryegrass, SD: Standard deviation, ***: p<0.001, The difference between treatment means without a small letter is significant (p<0.05), The difference between years means without a capital letter is significant (p<0.05).

vetch ratio in the mixture varied between 100% and 50%, the crude protein yields were found statistically insignificant (Table 3).

Other important quality features are ADF and NDF ratios of the hay. As a result of the variance analysis, it has been determined that the ADF and NDF ratios of the hay varied significantly ($p<0.001$) by years and treatments (Table 4 and 5). Since there was more Hungarian vetch in the hay in the first year, the ADF and NDF ratio was found to be lower than the second year. As expected, the highest ADF and NDF ratio was determined in the sole Italian ryegrass planting. As the Italian ryegrass ratio decreases in the mixture, the ADF and NDF ratios of the hay generally decreased. Legumes have a lower ADF and NDF ratio than grasses because there are differences between legumes and grasses in both tissue and cell wall structure (thickness and chemical structure) (Önal Aşcı and Eğritaş, 2017). In addition, since the Hungarian vetch has an indeterminant growth feature, the production of young tissues (new leaves, flowers, etc.) continued while the plant was in the generative period, while it was almost over in the Italian ryegrass. For all these reasons, while the lowest ADF and NDF ratios were obtained from sole Hungarian vetch planting, followed by 90% Hungarian vetch + 10% Italian ryegrass mixture and they were statistically in the same group. Kusvuran et al. (2014) reported similar results in Hungarian vetch and Italian ryegrass mixtures.

Table 4. Descriptive statistics and comparisons for ADF (%)

Treatments	2015-2016		2016-2017		Average	
	Mean	SD	Mean	SD	Mean	SD
100HV-0IR	29.46	0.81	31.37	1.71	30.41 c	1.61
90HV-10IR	30.74	0.74	31.61	0.68	31.18 bc	0.81
80HV-20IR	30.97	0.63	32.47	1.61	31.72 abc	1.39
70HV-30IR	31.37	0.15	33.13	1.19	32.25 ab	1.23
60HV-40IR	31.02	0.26	32.66	0.63	31.84 abc	0.98
50HV-50IR	31.02	0.63	33.04	1.21	32.03 ab	1.40
40HV-60IR	31.37	0.69	33.32	0.16	32.34 ab	1.14
30HV-70IR	32.13	0.52	33.66	0.49	32.90 a	0.94
20HV-80IR	32.12	0.75	34.23	0.58	33.17 a	1.29
10HV-90IR	32.34	1.01	33.83	0.29	33.09 a	1.05
0HV-100IR	32.51	0.91	33.89	1.53	33.20 a	1.38
Average	31.37 B	1.05	33.02 A	1.29		
p	Year= 0.000***, Treatment= 0.000***, Year×Treatment= 0.977					

HV: Hungarian vetch, IR: Italian ryegrass, SD: Standard deviation, ***: $p<0.001$, The difference between treatment means without a small letter is significant ($p<0.05$), The difference between years means without a capital letter is significant ($p<0.05$).

Table 5. Descriptive statistics and comparisons for NDF (%)

Treatments	2015-2016		2016-2017		Average	
	Mean	SD	Mean	SD	Mean	SD
100HV-0IR	36.75	0.60	38.06	1.38	37.40 e	1.21
90HV-10IR	40.60	0.63	41.43	1.44	41.01 de	1.12
80HV-20IR	41.49	0.68	45.42	3.76	43.46 bcd	3.27
70HV-30IR	42.11	0.63	44.60	2.17	43.35 cd	1.99
60HV-40IR	43.17	1.02	43.77	1.46	43.47 bcd	1.20
50HV-50IR	41.92	1.13	46.11	3.97	44.02 bcd	3.51
40HV-60IR	44.28	1.91	44.80	5.50	44.54 bcd	3.82
30HV-70IR	45.48	2.14	47.97	2.60	46.73 abc	2.57
20HV-80IR	45.10	1.07	49.07	2.48	47.09 ab	2.76
10HV-90IR	48.40	0.55	49.38	2.22	48.89 a	1.58
0HV-100IR	48.95	1.15	50.27	1.52	49.61 a	1.43
Average	43.48 B	3.54	45.53A	4.33		
p	Year= 0.000***, Treatment= 0.000***, Year×Treatment= 0.608					

HV: Hungarian vetch, IR: Italian ryegrass, SD: Standard deviation, ***: $p<0.001$, The difference between treatment means without a small letter is significant ($p<0.05$), The difference between years means without a capital letter is significant ($p<0.05$).

In mixtures, LER, aggression, and competition ratio are determined to reveal the competition between plants (Dhima et al., 2007). As a result of the analysis of variance, there was no difference between mixtures in terms of LER and competition ratio (Table 6). However, it has been determined

Table 6. Descriptive statistics and comparisons for LER value

Treatments	2015-2016		2016-2017		Average	
	Mean	SD	Mean	SD	Mean	SD
90HV-10IR	1.317	0.149	1.707	0.362	1.512	0.330
80HV-20IR	1.296	0.230	1.212	0.386	1.254	0.297
70HV-30IR	1.343	0.175	1.214	0.857	1.278	0.577
60HV-40IR	1.476	0.170	1.234	0.265	1.355	0.243
50HV-50IR	1.311	0.196	1.141	0.484	1.226	0.354
40HV-60IR	1.150	0.134	1.136	0.315	1.143	0.224
30HV-70IR	1.261	0.231	1.219	0.110	1.240	0.169
20HV-80IR	1.209	0.369	1.158	0.633	1.184	0.481
10HV-90IR	1.181	0.108	0.853	0.084	1.017	0.197
Average	1.283	0.206	1.208	0.449		
p	Year= 0.304, Treatment= 0.141, Year × Treatment= 0.543					

HV: Hungarian vetch, IR: Italian ryegrass, SD: Standard deviation

that all the mixtures were better than sole planting (LER> 1), and the 90% Hungarian vetch + 10% Italian ryegrass mixture had the highest LER value as 1.512. It has been revealed by many studies that mixtures have better results than sole plantings (Asci et al., 2015; Acar et al., 2017; Mut et al., 2017; Önal Aşcı and Eğritaş, 2017; Gulumser et al., 2018). The aggressivity and competition ratio of the plants have changed depending on the climate and mixture ratio and as a result of statistical analysis, the year × mixture interaction has been found significant ($p<0.01$) (Table 7-10).

In the first year, Italian ryegrass was the aggressive type in all mixtures (A_{IR} positive) and in the second year, it was also the aggressive type except for 90% Hungarian vetch + 10% Italian ryegrass mixture (A_{IR} positive) (Table 7). The opposite situation has been determined for the Hungarian vetch (Table 8). The power yield of Italian ryegrass increased in mixtures because of tillering and having N from the fixation of Hungarian vetch. Therefore, Italian ryegrass was observed as an aggressive type in the mixture.

Table 7. Descriptive statistics and comparisons for aggressivity (A_{IR})

Treatments	2015-2016		2016-2017	
	Mean	SD	Mean	SD
90HV-10IR	0.422Aa	0.417	-0.627Ba	0.564
80HV-20IR	0.344Aa	0.255	0.324ABa	0.619
70HV-30IR	0.348Aa	0.281	0.047ABa	0.820
60HV-40IR	0.423Aa	0.369	0.137ABa	0.238
50HV-50IR	0.382Aa	0.363	0.339ABa	0.388
40HV-60IR	0.306Aa	0.292	0.230ABa	0.900
30HV-70IR	0.362Aa	0.361	0.714Aa	0.424
20HV-80IR	0.476Aa	0.503	0.875Aa	0.469
10HV-90IR	0.255Aa	0.445	0.724Aa	0.057
p	Year= 0.485, Treatment= 0.010, Year×Treatment= 0.006**			

**: $p<0.01$, The difference between treatments means without a common capital letter in the same year is significant ($p<0.05$), The difference between years means without a common small letter in the same treatment is significant ($p<0.05$).

Table 8. Descriptive statistics and comparisons for aggressivity (A_{HV})

Treatments	2015-2016		2016-2017	
	Mean	SD	Mean	SD
90HV-10IR	-0.422Aa	0.417	0.627Aa	0.564
80HV-20IR	-0.344Aa	0.255	-0.324ABa	0.619
70HV-30IR	-0.348Aa	0.281	-0.047ABa	0.820
60HV-40IR	-0.423Aa	0.369	-0.137ABa	0.238
50HV-50IR	-0.382Aa	0.363	-0.339ABa	0.388
40HV-60IR	-0.306Aa	0.292	-0.230ABa	0.900
30HV-70IR	-0.362Aa	0.361	-0.714Ba	0.424
20HV-80IR	-0.476Aa	0.503	-0.875Ba	0.469
10HV-90IR	-0.255Aa	0.445	-0.724Ba	0.057
p	Year= 0.485, Treatment= 0.010, Year×Treatment= 0.006**			

HV: Hungarian vetch, IR: Italian ryegrass, SD: Standard deviation, **: $p<0.01$, The difference between treatments means without a common capital letter in the same year is significant ($p<0.05$), The difference between years means without a common small letter in the same treatment is significant ($p<0.05$).

Table 9. Descriptive statistics and comparisons for competition ratio (CR_{IR})

Treatments	2015-2016		2016-2017		Average	
	Mean	SD	Mean	SD	Mean	SD
90HV-10IR	4.445	2.727	5.307	4.408	4.876	3.425
80HV-20IR	2.617	1.112	10.855	13.701	6.736	10.018
70HV-30IR	1.694	0.834	5.269	3.385	3.482	2.977
60HV-40IR	1.831	0.490	2.020	0.609	1.926	0.521
50HV-50IR	0.903	0.447	59.843	116.129	30.373	82.294
40HV-60IR	1.114	0.452	3.386	4.069	2.250	2.942
30HV-70IR	1.070	0.245	3.435	3.518	2.253	2.632
20HV-80IR	0.690	0.397	1.792	0.688	1.163	0.764
10HV-90IR	1.154	0.488	4.392	5.572	2.773	4.050
Average	1.724	1.471	10.954	39.225		
p	Year= 0.147, Treatment= 0.568, Year×Treatment= 0.525					

HV: Hungarian vetch, IR: Italian ryegrass, SD: Standard deviation

Table 10. Descriptive statistics and comparisons for competition ratio (CR_{HV})

Treatments	2015-2016		2016-2017		Average	
	Mean	SD	Mean	SD	Mean	SD
90HV-10IR	4.445	2.727	5.307	4.408	4.876	3.425
80HV-20IR	2.617	1.112	10.855	13.701	6.736	10.018
70HV-30IR	1.694	0.834	5.269	3.385	3.482	2.977
60HV-40IR	1.831	0.490	2.020	0.609	1.926	0.521
50HV-50IR	0.903	0.447	59.843	116.129	30.373	82.294
40HV-60IR	1.114	0.452	3.386	4.069	2.250	2.942
30HV-70IR	1.070	0.245	3.435	3.518	2.253	2.632
20HV-80IR	0.690	0.397	1.792	0.688	1.163	0.764
10HV-90IR	1.154	0.488	4.392	5.572	2.773	4.050
Average	1.724	1.471	10.954	39.225		
p	Year= 0.714, Treatment= 0.056, Year×Treatment= 0.190					

HV: Hungarian vetch, IR: Italian ryegrass, SD: Standard deviation

4. Conclusions

As a result of a 2-year study in which the Hungarian vetch and Italian ryegrass were planted as a mixture at different ratios, it was determined that the mixing rate significantly affected the hay yield, crude protein, ADF, and NDF ratios. Considering the yield and quality data together, 90% Hungarian vetch + 10% Italian ryegrass mixture was better than other mixtures. There was no statistical difference between the land equivalent ratio (LER) values of the mixtures, however, Italian ryegrass was found to be more aggressive (A_{IR} positive) in the mixtures. As a consequence, in regions with similar climatic conditions, it can be recommended to culture 90% Hungarian vetch + 10% Italian ryegrass mixture for winter sowing.

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